Evaluation and Control of Facility Airborne Effluents

Purpose and Scope

The purpose of this Supplement is to assist program managers and facility designers in their efforts to ensure that effluents from contamination-control ventilation systems will not create hazards to people on or off site. Such systems are used throughout LLNL to protect people and the environment by controlling airborne toxic or radioactive contaminants. These emissions can be hazardous to employees if excessive concentrations of the contaminants reenter the building from which they are discharged, reenter adjacent buildings, or reach the ground on or off site. Rooftop workers will also be protected in most instances from exposure to excessive concentrations due to routine or accidental releases.

This Supplement serves as an aid for determining an appropriate exhaust stack location, stack height, and possible air-cleaning devices for building ventilation systems. Use of these guidelines should result in more consistent risk evaluations, system designs, and safe work areas.

However, this is not intended to be a design manual. The current state-of-the-art method of designing ventilation systems requires a case-by-case analysis. No set design rules or simple formulae will give optimum solutions for all situations. Experience at LLNL and elsewhere has shown that the use of stack-height techniques for dilution of toxic contaminants is empirical. The level of effort invested in these evaluations and their documentation should be proportional to the seriousness of exposure consequences (i.e., the effluent toxicity, concentration, quantity, impact on surrounding areas, and building reentrainment concerns). The information in appendices concerning dispersion models and tracer gas is provided as an aid to understanding, but these models are not sufficient by themselves. The Hazards Control Department will provide further references upon request.

It is essential that the Hazards Control, Environmental Protection, and Plant Engineering Departments—who share responsibility for this aspect of building design—be invited to participate at an early stage in all such exhaust-system designs.

Policy Statement

It is LLNL Policy that all operations will be conducted with minimal adverse impact on employees, the public, and the environment. Operations will comply with applicable DOE regulations concerning health, safety, and the environment. Adhering to the following elements will ensure the policy is achieved.

Policy Elements

- The best effluent exhaust system design does not dilute and disperse pollutants into the on-site and off-site environment. Wherever feasible, air-cleaning techniques shall be used to prevent significant releases.
- Accidental and routine release scenarios must be evaluated. Give consideration to administrative control measures (e.g., material limits, safety procedures, training, etc.) that may offset the risk to a level acceptable to management.
- Use the smallest quantities and the least toxic materials consistent with getting the job done.
- Release of radioactive and carcinogenic materials must be maintained as low as reasonably achievable.
- Ventilation systems are reviewed for specific materials and purposes. Changes in physical form, type, and quantity of materials and changes in process equipment must be reviewed by the Hazards Control and the Environmental Protection Departments to ensure that exposures to effluent air will remain acceptable.
- The stack height should be the maximum that is practical, subject to the requirements for dilution, dispersion, and elimination of unacceptable reentry through building openings.
- All stacks designed to dilute routine discharges by dispersion (e.g., those whose effluents have not gone through air cleaners or whose release at the stack exceeds a TLV or DAC) must be located such that the complete plume is above the building's recirculation cavity zone in order to ensure proper dispersion.

• On-site hazard assessments, safety analysis reports, and environmental assessments should be supported by consistent analyses and release scenarios.

• Standard methods (acceptable to Hazards Control) of calculating dispersion, tracer gas release, or scale modeling must be used in evaluating release scenarios.

• LLNL Management must understand and accept the risks of operating their facilities, and must provide for emission-control and monitoring equipment necessary for regulatory compliance. The Plant Engineering Department has design responsibility, and the Hazards Control and Environmental Protection Departments have review and oversight functions. Hazards Control is directly responsible for analysis of on-site consequences, including safety-related ventilation system parameters (e.g., face velocities, air cleaning, stack height, and material operating limits). Environmental Protection is responsible for analysis of off-site consequences, stack monitoring determinations, and compliance with environmental regulatory agency requirements.

Applicable General Design Standards

While no complete set of standards is available to solve effluent problems, this section describes those applicable standards required by DOE.

Exposure Levels

LLNL personnel must not be routinely exposed to levels exceeding the threshold limit values (TLV) of the American Conference of Governmental Industrial Hygienists.[1] For non-routine exposures such as could be encountered in an accidental release, exposures must not exceed the Immediately Dangerous to Life and Health (IDLH) concentrations specified by the National Institute of Occupational Safety and Health.[2] Exposure to radioactive materials must not exceed 5 rem / yr for occupational exposure and 25 mrem / yr at the site boundary.[3] Exposures to carcinogens and radioactive material must be maintained as low as reasonably achievable, since environmental protection standards exist for few specific chemicals. Also, there are broader requirements for permits, emissions inventories, and stack effluent monitoring.

Current information on regulatory compliance is available through the Hazards Control Safety Teams.

Stacks

The *ACGIH Industrial Ventilation Manual*[4] states that the discharge stack top must be sufficiently high relative to building height to prevent reentrainment through air inlets on the roof. The top of the stack should be from 1.3–2 times the height of the building for the ideal case of a low building without obstructions (e.g., other buildings, trees, architectural screens, etc.) and with reasonably level terrain. (See Figs. 1 and 2.) Design requirements for complex terrain are not given.

Highly toxic, radioactive, or carcinogenic effluents require treatment prior to intentional discharge. In the case of particulates, a high-efficiency particulate air (HEPA) filter with an efficiency of 99.97% for an in-place system test is normally required. Also, stacks intended to discharge contaminants should not have a rain cap installed, as it would deflect air toward the rooftop. See Fig. 3 for alternate designs.

Building Design

The DOE design criteria for buildings[10] references Chapter 14 of the 1985 *Fundamentals Handbook of the American Society of Heating, Refrigeration, and Air Conditioning Engineers.*[5] This chapter contains better guidelines for stack design than ACGIH.

Risk Analysis

For LLNL activities a new toxic ventilation system is required to have a safety analysis whereby the hazard has been characterized in terms of both routine and non-routine (accidental) exposure consequences. Based on the toxicity of the material, likelihood of release, and consequences of exposure, the system should be broadly classified as low, medium, or high risk. For further details on risk analyses, see *Health and Safety Manual* sections 2.04–2.06, *Health and Safety Manual* Supplement 33.42 (for radioactive materials), and Supplement 6.06, "Safety Analysis Guide." This will help retain some perspective about the level of risk involved as well as level of design effort needed to control the hazard. When accidental release consequences are severe, aspects of system design (e.g., Engineering Safety Notes) and work procedures (e.g., Operational Safety Procedures) will be considered in determining whether an operation constitutes a reasonable risk.

Recent environmental legislation will require increased use of risk assessments to determine whether certain emissions are permissible. The Environmental

Protection Department monitors these new requirements and will advise generators of compliance needs. Managers must be aware that safety-related legislation is increasing and moving into new areas with dynamic growth. Currently unregulated releases or operations may be affected in the future.

Ultimately, it is the decision of management whether or not to assume the risks inherent in the work, except for the situation where Hazards Control has determined that the operation or ventilation system design constitutes an imminent hazard of serious consequences (e.g., possible irreversible health effects). In this circumstance, Hazards Control is *required* to stop the operation.

Air Cleaners

HEPA Filters

As previously stated, a high efficiency (99.97% or greater for 0.3 µm particles) filter is needed to preclude discharge of significant amounts of radioactive, carcinogenic, or highly toxic particulates. Such filters require an annual system efficiency test and maintenance to ensure their continued effectiveness. See *Health and Safety Manual* Supplement 12.05 for more specifics.[8]

Scrubbers

Systems designed to remove a vapor or mist from discharged air using water sprays are generally referred to as *scrubbers*. These are not "off the shelf" items in the way that HEPA filters are. Their efficiency is highly variable with design and for specified contaminant(s), flow rates, physical states, etc. Scrubbers are maintenance intensive and may generate a toxic liquid disposal problem. Designs must be reviewed by Hazards Control prior to procurement.

Sorbents and Adsorbers

Systems that remove contaminants by reaction or physical adsorption usually bind the contaminant or its reaction product in a solid medium. This will necessitate disposal of the solid-waste, which is usually easier to handle and dispose of than liquid wastes.

Thermally Catalytic and Oxidizing Chambers

Many gases can be safely burned (oxidized) to a less-toxic effluent upon discharge. Catalytic converters that operate from ambient to elevated temperatures are also used to transform a highly toxic material to a less-toxic effluent.

Combinations

Because of physical characteristics, efficiency limitations, or effluent mixtures, combinations of air cleaners may be required to manage airborne discharges to acceptable limits.

Containment

Containment is preferable to release because it allows a number of options such as treatment or temporary holdup followed by slow, controlled release at acceptable concentrations. Unlike the treatment systems that are typically always online, a containment system must be activated at the critical time and must function reliably. Activation could be done automatically by a specific sensor that monitors the effluent. Maintenance of such a monitoring system is a high priority.

Design Considerations for Discharge of *Untreated Effluent*

Building Environment

An evaluation of the local environment is needed to determine stack placement. The evaluation should address the location of rooftop air conditioning inlets relative to the planned discharge location. Separation distances much greater than the 20 feet required by some codes are required. This applies in the vertical direction as well as the horizontal rooftop plan view. (See Appendix B for equations dealing with rooftop vent reentrainment.) Where the surrounding terrain has taller buildings and trees, studies have shown that effluent may be trapped or deflected to the rooftop and ground by recirculation. Where surrounding terrain is complex, local wind patterns could be very different from prevailing directions and velocities reported by the weather services.

Stack Height

While increasing stack height is an obvious solution for minimizing reentrainment and downwind exposure problems, it has some very definite limits related to structural support, cost, and aesthetics. Most laboratories have a point of diminishing returns where increasing the discharge height does not significantly improve dilution, and other means must be investigated. Stack height can be back-calculated from dispersion models by inserting the appropriate TLV or other exposure limit for the limiting concentration and solving for discharge height. A safety margin should be introduced to account for uncertainty of the model and weather variables: a reduction of the limiting concentration by an order of magnitude is recommended. Where high stacks are unfeasible or undesirable, additional measures must be employed to reduce the source term. These include coupling with other discharge effluents to gain dilution, minimizing the amount of toxic material in process, and using holdup and abatement treatment measures.

Recirculation Cavity

Each site must be evaluated for the presence of what is called the *turbulence cavity* or *recirculation zone* due to obstacles. Obstacles can be an architectural fence surrounding rooftop equipment, the "equivalent fence" caused by closely surrounding trees taller than the rooftop, or closely surrounding buildings. Obstacles can cause significant rooftop recirculation cavities from distances as far as 200–800 feet away in any direction not just upwind. See ASHRAE Chapter 14 for more details.[5]

Unless there is a nearly absolute air cleaning device on the system (e.g., HEPA filtration), it is essential to determine whether or not the discharge stack or intake vents are located in a cavity before applying any of the calculational models. If doubt exists, smoke tests or tracer gas tests can be conducted. A smoke will visibly show the presence of a cavity by swirling the plume downward toward the rooftop or ground rather than forming a cone shaped zone of dispersion. Data from tracer gas releases may identify the presence of a cavity by rooftop intake or building air concentrations that far exceed the values predicted by the calculational model. (See Appendices A–C.)

Once the presence of a cavity zone has been determined, the consequences must be quantified or the cavity corrected. Consequences may be predicted by scaling expected releases to results of a tracer gas test. If toxicity and resultant concentrations indicate that the reentrainment consequences from any release scenario are not significant (e.g. below 10% of TLV) then no further action is needed other than to obtain assurances that no more toxic material than what has been evaluated will be introduced into the system.

The cavity may be corrected by removal of the rooftop fence, trimming of surrounding trees, or increasing the stack height. Proper stack functioning should be demonstrated by smoke or tracer gas tests, depending on the level of concern.

It is worth repeating that calculational models may only be applied in circumstances where the rooftop recirculation cavity has already been evaluated, and the stack is known or judged to be dispersing in a reasonably correct fashion. Use of calculational models without cavity evaluation to design stacks is an incorrect application of the model with potentially dangerous consequences.

Meteorology

In practice, worst-case wind directions, speeds, and stabilities should be considered. In some cases restricting operations to only favorable weather conditions (e.g., absence of rain, fog, inversion, low wind speed, and specific direction[s]) will help reduce risks. Such reliance on administrative controls is not preferable to an engineered solution, however.

Pollution Control

The optimum method for dealing with a toxic effluent is to use an air-cleaning technology such as filtration, adsorption, catalysts, oxidizing chambers, scrubbing, or reacting to less-toxic products. Other than HEPA filtration, each is a case-basis engineering design whose efficiency and reliability need to be evaluated. Some applications may need combinations of the above devices to achieve an acceptable level of control. This is an expanding area of technology and some off-the-shelf designs are commercially available.

Materials considered slightly toxic or nontoxic to humans may be causes of air pollution, e.g. "nuisance" dust. Air pollution is to be considered in stack design; the Environmental Protection Department can supply guidance to planners and designers.

Modeling of Releases

Smoke Tests

Release of a colored smoke* through an existing system or at some height above the planned stack location can rapidly provide a qualitative graphic picture of exhaust plume behavior. Photos can be taken for a permanent record of the test. Tests should be repeated in a variety of wind speeds, wind directions, and atmospheric stabilities to provide a more complete picture of stack performance. The released cloud can be visually traced as it leaves the stack.

Tracer Gas Tests

A tracer gas release can be highly valuable in quantitatively measuring dilution and reentrainment. Although such testing is labor intensive and difficult to do well, it provides data that can be directly compared with calculated data (see below). Confidence improves by selecting a calculational model appropriate for the specific environment tested. Tracer tests should support the model, not replace it, since the test at best will represent only a few wind, direction,and stability scenarios. Tests should include at least the predominant wind direction and a low wind speed (i.e., below 5 mph).

In principle, a nontoxic, nonflammable, easily detected gas is released and then collected (using sample bags, charcoal, etc.) at a number of downwind locations. When comparing the model to tracer data, the uncertainty of the model and the sampling and analytical errors of the test gas need to be statistically indicated so that data are comparable. Some typical tracer gases are sulphur hexafluoride and Freon-12. See Appendix C for a sample method.

Calculational Models

When modeling release concentrations, one must take note of on-site and off-site concerns. For off-site concentrations, the Gaussian model is still the basic workhorse for dispersion calculations (see Appendix A). The Gaussian model is not intended for use at distances less than 100 m. Other models intended for lesser distances (i.e., <100 m) should be used, such as the D. J. Wilson model (see Appendix B).** Software for many models is commercially available. Most calculational models are invalid if a stack discharge is physically located in a turbulence cavity.

Scale Models

An actual scale model of the building and its local environment may be constructed and subjected to wind tunnel tests to study recirculation wake effects of upwind and downwind obstructions on a proposed building design. This type of testing is useful to optimize building configuration and stack location. It is costly and is most useful when the model is fully rotatable, simulating all wind directions where stack releases are measured quantitatively. It is possible to simulate most stability classes, however.

Summary

The current state of the art does not safely permit a generic or fixed approach to system design that will prevent reentrainment. The principal considerations in the design and evaluation of a ventilation system to control building reentrainment and downwind exposures have been introduced. Exactly which evaluation techniques and engineering controls are needed to control a toxic discharge is a matter of both professional and management judgment. Each system design is a unique case. In many instances, hazards can be most effectively confined and contained at the point of origin—e.g., the hood or work exposure. Most of the control principles described above are effective on a small scale, too, and bring economic benefits when located at the source.

In general, the more serious the potential exposure, the greater the effort is warranted in both the evaluation and the system's design. Plant Engineering has design authority; Hazards Control has health and safety review oversight; Environmental Protection performs off-site evaluations and, if needed, stack monitoring—but it is management that must accept the risk of operating the facility.

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* Smoke release tests must be coordinated through the Hazards Control Fire Department and are best conducted during after-hours if reentrainment is likely.

**Note: The descriptive information is Appendix A and B is not sufficient to allow correct use of those models. It will be necessary to consult more detailed references

References

1. American Conference of Governmental Industrial Hygienists, “Threshold Limit Values and Biological Exposure Indices, 1987–1988,” American Conference of Governmental Industrial Hygienists, Cincinnati, OH.

2. National Institute of Occupational Safety and Health, *NIOSH Pocket Guide to Chemical Hazards*, U.S. Department of Health, Education, and Welfare (National Institute of Occupational Safety and Health), Washington, D.C., NIOSH Publication No. 78-210 (1984).

3. LLNL *Health and Safety Manual*, Chapter 33, “Radiation—Ionizing,” Lawrence Livermore National Laboratory, Livermore, CA, M-010 (1988).

4. American Conference of Governmental Industrial Hygienists, *Industrial Ventilation: A Manual of Recommended Practice*, 19th Edition, American Conference of Governmental Industrial Hygienists, Cincinnati, Ohio (1986).

5. American Society of Heating, Refrigeration, and Air conditioning Engineers, “Fundamentals Handbook of the American Society of Heating, Refrigeration, and Air Conditioning Engineers, 1985,” American Society of Heating, Refrigeration, and Air Conditioning Engineers, Atlanta, GA (1985).

6. D.J. Wilson, “Along-Wind Diffusion of Source Transients,” *Atmospheric Environment*, Vol. 15, pp. 489-495 (1983).

7. K. Wark and C.F. Warner, *Air Pollution: Its Origin and Control*, Second Edition (Harper and Row, New York, 1981).

8. LLNL *Health and Safety Manual* Supplement 12.05, “HEPA Filter Systems Design and Testing.”

9. S. Hanna, G. Griggs, and R. Hosker, *Handbook on Atmospheric Diffusion*, U.S. Department of Energy, Washington, D.C., DOE/TIC-11223 (1982).

10. U.S. Department of Energy, DOE Order 6430.1A, U.S. Department of Energy, Washington, D.C.

Appendix A

Distant, Off-Site Model: The Gaussian Dispersion Model

The Gaussian model assumes a normal distribution along axis profiles (see Figure A-1, below) and is generally considered a practical model for distances beyond 0.1 Km. Below, a brief presentation of the equations and variables is presented for an overview of this method and an appreciation for its complexity. This model should not be used on the basis of this information alone; it is essential to consult a textbook to obtain detailed explanation of how to apply the model to a given situation. For more details, see Ref. 9

$$C\,(x,y,H) = \frac{Q}{\pi \sigma_y \sigma_x U} \ \exp\left[-\frac{1}{2}\left(\frac{y}{\sigma_y}\right)^2\right] \exp\left[\ -\frac{1}{2}\left(\frac{H}{\sigma_z}\right)^2\right]$$

where: C = Ground-level concentration (g/m^3 or Ci/m^3)

x = Distance downwind in the direction of the mean wind

y = Crosswind distance

Q = g/s or Ci/s

σ_y = Standard deviation of concentration distribution in horizontal direction (m)

σ_z = Standard deviations of concentration distribution in vertical direction (m)

U = Wind speed (m/s)

H = Effective source height

Figure A-1. Concentration profiles along the center line in the x-direction and in the z-direction.

Table A-1. Key to stability categories.

Surface wind speed at 10 m (m/s)	Day: Incoming solar radiation			Night: Cloud cover	
	Strong	Moderate	Slight	Mostly overcast	Mostly clear
Class[a]	(1)	(2)	(3)	(4)	(5)
<2	A	A-B	B	E	F
2-3	A-B	B	C	E	F
3-5	B	B-C	C	D	E
5-6	C	C-D	D	D	D
>6	C	D	D	D	D

[a]The neutral class, D, should be assumed for overcast conditions during day or night. Class A is the most unstable and Class F is the most stable, with Class B moderately unstable and Class E slightly stable.

Source: D. B. Turner, *Workbook of Atmospheric Dispersion Estimates*, Washington, D.C.: HEW, 1969.

Table A-2. Approximate values of σ_y and σ_z as a function of downwind distance for various stability classes, in meters

Distance	Stability classes and σ_y values						Stability classes and σ_z values					
(km)	A	B	C	D	E	F	A	B	C	D	E	F
0.1	27	19	13	8	6	4	14	11	7	5	4	2
0.2	50	36	23	15	11	8	29	20	14	8	6	4
0.4	94	67	44	29	21	14	72	40	26	15	11	7
0.7	155	112	74	48	36	24	215	73	43	24	17	11
1.0	215	155	105	68	51	34	455	110	61	32	21	14
2.0	390	295	200	130	96	64	1950	230	115	50	34	22
4.0		550	370	245	180	120		500	220	77	49	31
7.0		880	610	400	300	200		780	360	109	66	39
10.0		1190	840	550	420	275		1350	510	135	79	46
20.0		2150	1540	1000	760	500		290	950	205	110	60

Source: D. B. Turner, Workbook of Atmospheric Dispersion Estimates, Washington, D.C.: HEW, Rev., 1969.

Appendix B

Local, Distant, Off-Site Model: D. J. Wilson

The Wilson model is one of several models designed to predict dispersion at distances near the source (e.g., <0.1 km) where the Gaussian model is known to over-predict concentrations. One other advantage of this model is that it is based on empirical data that incorporates worst-case wind conditions in all directions. Figure B-1 below illustrates plume trajectory with downwash and effective stack height. Figure B-2 illustrates the recirculation cavity, upwind frontal area and proper plume release. As with the Gaussian model discussed in Appendix A, potential users must obtain a more detailed description than presented herebefore attempting to use this model. For more complete details, see Ref. 6.

Formulas used:

$$D_t = D_w \times D_s \times D_i$$

$$D_w = \left[1 + 1.48 \left(\frac{s}{\sqrt{A_e}} \right)^{0.5} \right]^2$$

$$D_s = \exp\left[\left(4.23 \frac{h_s}{s} + 0.707\beta \right)^2 \right]$$

$$D_i = Q_s \bigg/ \frac{W\ T\ R}{(P)\,(MW)\,(28.32)}$$

or

$$D_i = Q_s / V$$

where,

D_t = Total dilution
D_w = Dilution due to wind
D_s = Dilution due to stack height
D_i = Dilution of system
s = "Stretched string" distance between vent and intake for zero stack height
A_e = Exhaust flow area, ft^2
h_s = Effective stack height above rooftop obstacles (ft). (The h_s value is calculated by subtracting tree height plus a downdraft correction factor H_c from stack height. $H_c = 0.3\,(A_r)^{0.5}$, where A_r is the area of the obstacle.)

β	=	capping factor, ß = 0 with raincap, and ß = 1 with no obstruction
Q_S	=	cfm or airflow in stack
W	=	Release rate in grams / min of compound of concern
T	=	Temperature in K
P	=	Pressure in atmospheres
MW	=	Molecular weight of compound of concern
V	=	Release rate (cfm) of compound of concern
R	=	Ideal gas law constant (0.08206)

“Stretched string” distance between vent and intake (m).

Appendix C

Example of SF_6 Tracer Gas Release Method

Twenty-minute air samples are collected in mylar sample bags connected to a calibrated sampling pump operating at 75 cm^3/ min. SF_6 gas is released inside the gas manifold hood for a period of 30 minutes at a rate of 5 SCFM. The prevailing wind direction for each test must be obtained (e.g., from the LLNL site meteorological tower located near Building 594 at a height of 120 ft). These data are automatically integrated and corrected every 15 minutes. A prevailing wind direction is needed to determine which set of a grid of predetermined sampling points to use. Wind data at the release location may be visually monitored using anemometer and directional monitor gauges located near the release site. These measurements should agree well with the site prevailing wind direction, but they are subject to instantaneous fluctuations that make them difficult to use without integration.

Measurements should be taken at the base of the stack and on 200, 300, 400, and 600 ft arcs in the downwind direction because this is the range of maximum readings predicted by the Wilson model for nominal release conditions.[6] Sampling points should located off axis from and below the prevailing wind direction to anticipate fluctuations during the release period.

Hazards Control has analyzed samples in a portable gas chromatograph with an analytical error of <10% reported by the manufacturer. Assuming an estimated sampling error for gas bag sampling of ±15, the combined sampling and analytical error may be estimated to be ±25%.

Appendix D

Smoke-Release Methods

An existing exhaust stack can be quickly and graphically evaluated with this qualitative, but relatively simple test. Colored smoke bombs (M-40) are released inside a hood or on the rooftop, inserted upstream of the exhaust fan. Great care must be used since the heat released by these smoke bombs is sufficient to burn through most duct work, and a residue is deposited on surfaces in contact with the smoke. For these reasons and to prevent alarming other workers, smoke-release tests should *always be coordinated with the LLNL Fire Department.*

Arrangements should be made to photograph the resultant smoke plumes to provide a permanent record of the test. Bear in mind that it is impractical to conduct these tests in all wind directions, speeds, and atmospheric stability conditions. Meteorological conditions should be previously determined to be worst case; otherwise, results can be misleading. Despite the difficulties this is a very practical test method to visually evaluate the performance of an existing exhaust system.

Appendix E

Minimum Contents of Analysis Reports

No fixed format of reports will suit all situations. However, to insure consistency of analyses, at least the points listed below should be addressed:

I. Purpose
II. Background
III. Recommendations
IV. Materials
V. Exposure Limits
VI. Release Scenario(s) and System Description
VII. Evaluation Method(s)
VIII. Assumptions of the Analysis
IX. Safety Margin
X. Analysis Results
XI. Risk Assessment

Other Appendices